

Examining the roles of students' beliefs and security concerns for using smartwatches in higher education

Abstract

Purpose- Despite the increased use of wearables in education, little attention has been paid to why some students are more likely to adopt smartwatches than others. The question of what impacts the adoption of smartwatches in educational activities is still neglected. In addition, the question of how security determinants can affect the adoption of smartwatches by students has not been addressed yet. Hence, this research develops a theoretical model by integrating the technology acceptance model (TAM) and protection motivation theory (PMT) to study students' adoption of smartwatches for educational purposes.

Design/methodology/approach- Questionnaires were distributed to university students in Malaysia. A total of 679 valid responses were collected. The collected data were analyzed using partial least squares-structural equation modeling (PLS-SEM).

Findings- The results of data analysis provide support for the proposed model. Furthermore, the findings indicated that perceived vulnerability, self-efficacy, response efficacy, response cost, ease of use, and perceived usefulness have significant effects on students' behavioral intention to use smartwatches for educational purposes. In addition, perceived ease of use of smartwatches for educational purposes helps students to realize the benefits of this technology.

Originality/value- This is an original study that develops a new holistic theoretical model by combining the PMT and TAM to study the effects of ease of use, usefulness, and security-related factors on the adoption of smartwatches for educational purposes. The study offers practical implications for universities and higher education institutions to improve students' learning experiences to ensure their sustainability using new and innovative ways by exploiting new technologies such as smartwatches.

Keywords: wearable technology; smartwatches; individuals' beliefs; security concerns; TAM; PMT.

1. Introduction

Over the past few years, the world witnessed an increasing interest in the use of wearable technologies (Bölen, 2020). Wearable technologies are seen to be practical, futuristic, exciting, and capturing the attention and interest of people who might not otherwise be drawn to technology. Despite its early stages of adoption, smartwatches represent the most famous product of wearable technologies (Chuah *et al.*, 2016). By crossing the borders of fashion and technology, smartwatches are believed to gain much popularity with significant growing forecasts (Chuah, 2019). In this sense, the International Data Corporation (IDC) indicated that smartwatches represent the first largest category of wearables; they accounted for 44.2% of the entire wearables market in 2018, while its share is predicted to reach 47.1% in 2023 (IDC, 2019). Smartwatches enable individuals to receive and respond to notifications instantly and afford a number of healthcare-based apps to measure their fitness activities and workouts at their convenience (Hong, Lin and Hsieh, 2017).

For education, there has been an increasing amount of literature on the use of wearable technologies for learning and teaching purposes. Wearable devices such as smartphones, smartwatches, fitness trackers, smart glasses, smart clothing, and personalized gadgets have faced significant developments and are increasingly becoming popular in educational activities (Alexander *et al.*, 2019). Namely, the new educational technologies, like virtual, augmented, and mixed reality, comprise real and virtual combined environments and human-machine interactions generated by computer technology and different wearable devices (Becker *et al.*, 2018). Wearables can be used to make learning and teaching experiences intrinsically motivating and more relevant to youth culture. In particular, smartwatches can be used to track students' activities and share their achievements (Elton, 2019). Smartwatches can also be used to play various educational games and record instructional lessons.

Despite its significant features, several issues have been observed concerning the use of smartwatches for educational purposes. First, while most of the previous research focused on examining the determinants affecting the adoption of smartwatches for communication purposes (Kim and Shin, 2015; Hsiao, 2017; Dutot, Bhatiasavi and Bellallahom, 2019), it has been suggested that there is a scarce of knowledge concerning the factors affecting the use of these wearables for educational purposes (Al-Emran *et al.*, 2020). Second, while individuals' beliefs like

“perceived ease of use” and “perceived usefulness” of smartwatches were regarded as the essential determinants for adopting smartwatches (Chuah *et al.*, 2016), the question of how these beliefs would influence the adoption of smartwatches by students remains unanswered. Third, although smartwatches provide instant access to messages, emails, and apps, some of these devices do not have a strong history when it comes to security (Symanovich, 2019). These wearable devices suffer from insufficient user authentication. Further, the severity of security threats might affect the use of smartwatches for educational purposes. This makes it difficult for students to manage how the learning content is being accessed. Fourth, since smartwatches are categorized under the family of smartphones, their use can expose several risks to institutions, such as data leakage, malware, network connectivity of the device (e.g., Bluetooth and WiFi), theft or loss of the device, and the access to several web-based applications (Weber and Rudman, 2018). Thus, the question of how security determinants would affect the adoption of smartwatches by students remains vague. These arguments are supported by the results of the bibliometric analysis (Al-Emran *et al.*, 2020) and review results (Bölen, 2020) provided in these two recent studies, in which security concerns have not yet been examined to understand the students’ behavioral intention to use smartwatches for instructional purposes. The understanding of these determinants would enable the decision-makers in higher educational institutions to develop more effective policies for securing the use of these wearables for instructional activities.

To handle the above gaps, this research examines the impact of individuals’ beliefs and security concerns on students’ behavioral intention to adopt smartwatches for educational purposes. In doing so, this research develops a theoretical model grounded on the technology acceptance model (TAM) (Davis, 1989) and protection motivation theory (PMT) (Rogers, 1975). The selection of these two theories stems from several reasons. First, these two theories are among the most cited theories in the areas of technology adoption and information security. Second, understanding the role of individuals’ beliefs can be served through the lenses of TAM, while explaining the role of security concerns in affecting students’ decisions to adopt smartwatches can be achieved through the perspective of PMT. Third, while the integration of these two models has already been validated in the previous literature (Chon *et al.*, 2018; Alexandrou and Chen, 2019), it is believed that smartwatches have distinct features (Ogbanufe and Gerhart, 2018), and it is expected that the factors affecting the students’ adoption of these wearables would also be different. Smartwatches are characterized by several features, such as non-visual aesthetics, high-pitched voices, and touch-

sensitive screens (Bölen, 2020). In addition, the nature of convenience smartwatches provide, their proximity to the body, and haptics feedback make these wearables distinct from other technologies (Ogbanufe and Gerhart, 2018).

The proposed model was then validated by collecting data from students studying at five different universities in Malaysia. The low adoption rates of smartwatches in Malaysia, in which user penetration is recorded as 3.5% in 2020, and it is expected to increase to 3.6% in 2024 (Statista, 2020) have attracted us to select Malaysia as a study context. Thus, the understanding of the individuals' beliefs and security concerns would help in providing insights into the low adoption rates and provide several implications for theory and practice.

Following this section, the next section provides the literature review, including a background on smartwatches in education, TAM in education, and PMT in education. The third section tackles the proposed theoretical model and its underlying hypotheses. The research methodology and results were then presented in sections four and five, respectively. The research findings are discussed in section six. Section seven provides the theoretical contributions and practical implications. Section eight provides the limitations and suggestions for future research directions. Section nine concludes the study by indicating its key findings.

2. Literature review

2.1 Smartwatches in education

Despite the benefits of using smartwatches in education, very few studies have explored its application for educational purposes. In general, little is understood on how to design wearables for education. Shadiev, Hwang and Liu (2018) designed an English as a foreign language (EFL) learning activity supported by smartwatches in order to combine EFL learning with physical exercise such as walking around the school community, while Fučeková and Metruk (2018) examined the possibilities of learning English through mobile applications, in particular, the smartwatch, smartphone, and tablet. The research conducted by De Arriba-Pérez, Caeiro-Rodríguez and Santos-Gago (2017) aimed to assess if consumer electronics wrist wearables, specifically smartwatches and smart bands, can be used to provide indicators of interest for educational purposes. The authors focused on the provision of enriched student profiles, involving not just academic data but also data related to the psychological and physiological state of the student. The authors found that smartwatches can be successfully used in this context. Further,

Seim *et al.* (2018) presented a case of using a smartwatch for passive tactile learning. The authors found that haptic technology can be used as a tool for learning, and whether the haptic elements in a smartwatch can teach a new skill. Table 1 provides a summary of the most recent studies focusing on smartwatches in education.

Table 1. Examples of recent studies focusing on the use of smartwatches among students.

The analysis in Table 1 shows that there are some studies focusing on the use and design of smartwatches among university students. However, the gap in understanding students' concerns and security issues associated with their use of smartwatches for learning remains open. Hence, the present study advanced existing knowledge by providing a better theoretical and empirical understanding of these issues.

2.2 Technology acceptance model in the educational context

From the vast stream of research, the TAM developed by Davis (1989) has emerged over the past three decades as a powerful model to represent the antecedents of technology usage through beliefs about two factors, namely “perceived ease of use” and “perceived usefulness”. Davis hypothesized that those two core TAM variables could influence the attitude of a user towards a specific technology, which in turn, changes the behavioral intention to use technology and its actual usage behavior. According to the original TAM, these two beliefs were hypothesized to be directly influenced by the system design characteristics or other external factors.

A vast number of acceptance studies have been carried out in the educational context, thus showing that TAM has emerged as a leading scientific paradigm for studying the acceptance of learning technologies (Granić and Marangunić, 2019). Empirical evidence for the predictive validity of TAM has been provided for e-learning (Weerasinghe and Hindagolla, 2017; Esteban-Millat *et al.*, 2018), m-learning (Joo, Lee and Ham, 2014; Almaiah, Jalil and Man, 2016), blended learning (Song and Kong, 2017), interactive whiteboards (Kilic *et al.*, 2015), personal learning environments (Del Barrio-García, Arquero and Romero-Frías, 2015), virtual learning environments (VLEs) (Tarhini *et al.*, 2015), and learning management systems (LMSs) (Jamil, 2017; Nagy, 2018), among many others.

The state-of-the-art of research efforts on the application of TAM in a variety of learning domains, learning technologies, and types of users has been presented by Granić and Marangunić (2019).

Furthermore, various TAM reviews and meta-analysis were conducted in order to provide insight into the current research trends in specific educational topics. For instance, the meta-analysis aiming to identify which factors in TAM might affect instructors' adoption of technology (Scherer, Siddiq and Tondeur, 2019), the systematic review which synthesized and reviewed the current trend of TAM research related to m-learning (Al-Emran, Mezhuyev and Kamaludin, 2018), the quantitative meta-analysis targeting the identification of the most commonly used external factors of TAM in the context of e-learning adoption (Abdullah and Ward, 2016; Salloum *et al.*, 2019), and the meta-analysis of e-learning technology acceptance intending to search for the mean causal effect size in TAM-related causal relationships (Šumak, Heričko and Pušnik, 2011).

2.3 Protection motivation theory in the educational context

The PMT is connected with a well-established theoretical tradition and may be considered as a special case of a more general category of theories that employing “expectancy” and “value” constructs (Rogers, 1975). Rogers postulated the three crucial components of a fear appeal to be the magnitude of noxiousness of a depicted event, the probability of that event's occurrence, and the efficacy of a protective response. Each of these communication variables initiates corresponding cognitive appraisal processes that mediate attitude change. Rogers hypothesized that protection motivation arises from the cognitive appraisal of a depicted event as noxious (appraised severity) and likely to occur (expectancy of exposure), along with the belief that a recommended coping response can effectively prevent the occurrence of the aversive event (belief in the efficacy of coping response). These cognitive processes mediate the persuasive effects of a fear appeal by arousing protection motivation, an intervening variable that stimulates, sustains, and directs activity to protect the self from danger.

Since its introduction in 1975, PMT has been widely adopted as a framework for the prediction of and intervention in health-related behavior (Milne, Sheeran and Orbell, 2000). As a well-established preventive health model, PMT has been utilized in a variety of health education domains. For instance, programs prepared for the prevention of self-medication by elders (Hatamzadeh *et al.*, 2017), health education materials on malaria preventive behaviors (Ghahremani, Faryabi and Kaveh, 2014), psychosocial intervention presented to patients undergoing bariatric surgery (Boeka, Prentice-Dunn and Lokken, 2010), educational interventions among cement factory workers (Mohammad Nabizadeh *et al.*, 2018), HIV/AIDS prevention

intervention programs among preadolescents (Gong *et al.*, 2009), educational booklets in an educational program about sexually transmitted infections (Jeong, Cha and Lee, 2017), prevention programs handling the risk of date rape without victim-blaming (Singh, Orwat and Grossman, 2011), evaluation of adolescent sexual health programs (Pham *et al.*, 2012), production of video curriculum for a blood borne pathogens training program for hospital nurses (Sinclair *et al.*, 1996), and the development of educational video to improve patient knowledge and communication with their healthcare providers about colorectal cancer screening (Katz *et al.*, 2009).

Besides health education practice, a number of protection motivation studies have explored the PMT applicability in some other education areas. For instance, Feenstra, Ruiter, and Kok (2014) have studied the influence of the adolescent bicycle safety education program on concepts derived from PMT. Poong, Yamaguchi, and Takada (2015) have addressed the need to systematically design learning content prepared according to PMT to promote world heritage site preservation awareness, while the effectiveness of integrating exergaming into physical education classes as a program for communicating health education messages based on PMT was examined by Lwin and Malik (2014).

3. Research model and hypotheses development

To fully understand students' behavioral intention to adopt smartwatch devices in learning activities, we developed an integrated theoretical model that combines the Protection Motivation Theory (PMT) (Rogers, 1975) and Technology Acceptance Model (TAM) (Davis, 1989). The selection of these two theories stems from the fact in which there is a scarce of knowledge regarding the understanding of the impact of security concerns (in terms of PMT) and individuals' beliefs (in terms of TAM) on the behavioral intention to adopt smartwatches for educational purposes. In comparison with other technology acceptance models, TAM is regarded to be a well-researched model that has an effective explanatory power and has been validated across a number of measurement scales (Venkatesh and Bala, 2008) for understanding the behavioral intention towards various technologies (Marangunić and Granić, 2015). Figure 1 depicts the developed research model and its underlying constructs.

Figure 1. Research model.

3.1 Perceived severity

Perceived severity refers to “the degree of physical harm, psychological harm, social threats, economic harm, dangers to others rather than oneself, and even threats to other species” (Rogers and Prentice-Dunn, 1997). Perceived severity was found to positively affect the individuals’ behavioral intention to adopt anti-spyware software (Chenoweth, Minch and Gattiker, 2009), cloud computing services (Ab Rahman and Choo, 2015), and healthcare wearable devices (Gao, Li and Luo, 2015). In the context of smartwatch, if students have strong perceptions on the severity of a threat, it can motivate them to avoid security incidents. We, therefore, hypothesize the following:

H1: Perceived severity has a significant positive effect on students’ behavioral intention to adopt a smartwatch.

3.2 Perceived vulnerability

Perceived vulnerability refers to “the conditional probability that the threatening event will occur provided that no adaptive behavior is performed or there is no modification of an existing behavioral disposition” (Rogers and Prentice-Dunn, 1997). The strong perception of security vulnerabilities can motivate students to avoid security breaches. Perceived vulnerability was shown to positively impact the individuals’ behavioral intentions to adopt anti-spyware software (Chenoweth, Minch and Gattiker, 2009), IS security (Siponen, Pahnla and Mahmood, 2007), cloud computing services (Ab Rahman and Choo, 2015), and healthcare wearable devices (Gao, Li and Luo, 2015). Concerning smartwatch, if students have a keen awareness of security vulnerability, this can encourage them to avoid security incidents. Thus, we hypothesize the following:

H2: Perceived vulnerability has a significant positive effect on students’ behavioral intention to adopt a smartwatch.

3.3 Self-efficacy

Self-efficacy can be defined as “the level of confidence of individual in their ability to perform the coping behavior” (Sergueeva and Shaw, 2017). Self-efficacy was found to positively influence the users’ behavioral intention to adopt various technologies (Woon, Tan and Low, 2005; Chenoweth, Minch and Gattiker, 2009; Ab Rahman and Choo, 2015; Gao, Li and Luo, 2015; Hsieh *et al.*, 2017; Verkijika, 2018). Hence, we hypothesize the following:

H3: Self-efficacy has a significant positive effect on students' behavioral intention to adopt a smartwatch.

3.4 Response efficacy

Response efficacy refers to the beliefs to which a recommended response would significantly protect individuals from a threat (Johnston and Warkentin, 2010). Response efficacy was found to have a significant positive influence on individuals' behavioral intentions to adopt anti-spyware software (Chenoweth, Minch and Gattiker, 2009), wearable devices (Sergueeva and Shaw, 2017), cloud computing services (Ab Rahman and Choo, 2015), and health record systems (Hsieh *et al.*, 2017). In the context of this study, response efficacy is suggested to have a positive correlation with the students' behavioral intention to adopt a smartwatch where students can practice the recommended security behavior successfully. We, therefore, hypothesize the following:

H4: Response efficacy has a significant positive effect on students' behavioral intention to adopt a smartwatch.

3.5 Response costs

Response costs can refer to any costs (e.g., effort, time, difficulty, and side-effects) associated with the recommended behavior (Rogers and Prentice-Dunn, 1997). Response cost was found to negatively affect the adoption of anti-plagiarism software (Lee, 2011), Bring Your Own Device (BYOD) practices (Dang-Pham and Pittayachawan, 2015), and online security behaviors (Tsai *et al.*, 2016). In this context, if students take a lot of effort in using the smartwatch or a significant amount of money is spent on the cost of purchasing and updating the software, this would negatively affect their behavioral intention. Based on that, we suggest the following:

H5: Response costs has a significant negative effect on students' behavioral intention to adopt a smartwatch.

3.6 Perceived ease of use

Perceived ease of use (PEOU) refers to "the degree to which a person believes that using a particular system would be free from effort" (Davis, 1989). It is suggested that the higher the PEOU of any system, the higher the perceived usefulness (PU) will be (Elkhani, Soltani and Ahmad, 2014). The literature also supported the correlation between PEOU and the behavioral intention to adopt a wide range of technologies (Salloum *et al.*, 2019; Al-Emran and Teo, 2020;

Al-Emran, Arpaci and Salloum, 2020; Rafique *et al.*, 2020). Thus, the following hypotheses were suggested:

H6: Perceived ease of use has a significant positive effect on the perceived usefulness of a smartwatch.

H7: Perceived ease of use has a significant positive effect on students' behavioral intention to adopt a smartwatch.

3.7 Perceived usefulness

Perceived usefulness (PU) is defined as “the degree to which a person believes that using a particular system would enhance his or her job performance” (Davis, 1989). The usefulness in this study refers to the students' perceptions in which adopting the smartwatch would increase their learning performance. The correlation between PU and behavioral intention has been validated in several studies conducted in the past (Al-Emran and Teo, 2020; Kamal, Shafiq and Kakria, 2020; Rafique *et al.*, 2020). Accordingly, the following is suggested:

H8: Perceived usefulness has a significant positive effect on students' behavioral intention to adopt a smartwatch.

4. Research methodology

This study follows the onion research method developed by Saunders, Lewis and Thornhill (2012). Figure 2 shows the research design diagram. In that, a mono quantitative approach has been selected to direct this study by focusing on the positivist paradigm as a research philosophy. The positivist paradigm is known as a quantitative, objective, scientific, experimentalist, or traditionalist research paradigm (Collis and Hussey, 2003; Saunders, Lewis and Thornhill, 2012). Positivism is usually the most predominant research paradigm used in the IS discipline (Chen and Hirschheim, 2004).

According to Lune and Berg (2016), positivist research usually employs the deductive reasoning process as a research approach. This approach is considered accurate and reliable in terms of validity and reliability. By applying the quantitative research method, this would help in examining and validating the hypothesized relationships among the variables in the research model. As such, a cross-sectional time frame was used by employing a questionnaire survey as a strategy to collect data from students studying at five different universities in Malaysia for validating the proposed

model and testing the hypothesized relationships. The partial least squares-structural equation modeling (PLS-SEM) using SmartPLS software was used to analyze the data.

Figure 2. Research design diagram.

4.1 Context and subjects

The data were collected using an online survey. The target participants were students studying at five different universities in Malaysia. The main reason behind the selection of Malaysia refers to the low adoption rates of smartwatches by end-users (Statista, 2020). Both undergraduate and postgraduate students have participated in the study through a convenience sampling technique. This technique enables the collection of the required sample size in a relatively fast and inexpensive way. The students were informed about the purpose of the research, and they were also told that their participation is voluntary, and they can withdraw at any time. The ethical approval was obtained electronically from all the participants. The survey was designed to be completed in not more than 10 minutes. Over a period of one month between December 2019 and January 2020, a total of 725 students participated in the study. Due to the large number of incomplete responses, 46 responses were discarded. As a result, a total of 679 valid responses were retained for further analysis.

4.2 Research instrument

An online survey consisting of two parts was used to measure the students' behavioral intention to use a smartwatch. The first part involves questions related to measure the students' demographic information, while the second part consists of questions related to measure the constructs in the proposed research model. A five-point Likert scale with values ranged from "1 = strongly disagree" to "5 = strongly agree" was used to measure the items of each construct. The items used to measure the perceived usefulness, perceived ease of use, and behavioral intention were adopted from Davis (1989) and Venkatesh and Bala (2008). The items used to measure perceived severity were taken from Foth, Schusterschitz, and Flatscher-Thöni (2012) and Lee and Larsen (2009), while the items used to measure perceived vulnerability were adopted from Lee (2011) and Ameen, Tarhini, Hussain Shah, and Madichie (2020). The items used to measure response costs and response efficacy were adopted from Lee and Larsen (2009) and Ameen et al. (2020), whereas the

items used to measure self-efficacy were adopted from Compeau and Higgins (1995). The constructs and their underlying items are listed in the Appendix.

Before conducting the study, the instrument has been pilot tested in order to measure the reliability of its items. Prior research suggested that the minimum number of participants in pilot studies is 30 (Hunt, Sparkman Jr and Wilcox, 1982). Accordingly, 48 students participated in the pilot study. For measuring the reliability of the instrument items, the Cronbach's alpha test was used. It has been suggested that the Cronbach's alpha values should be equal to or greater than 0.7 in order to indicate the reliability of the items (Hair *et al.*, 2010). For this research, the pilot study results indicated that the values of Cronbach's alpha for all the items were above the threshold value of 0.7. This suggests that the instrument items are reliable and can be used in conducting the study.

4.3 Data analysis

This research study employs the partial least squares-structural equation modeling (PLS-SEM) using the SmartPLS tool to analyze the collected data (Ringle, Wende and Becker, 2015). The collected data were analyzed using a two-step analytical technique, namely the measurement model and structural model (Hair *et al.*, 2017). The employment of PLS-SEM in this study stems from several distinct reasons. First, this study contributes to the development of TAM and PMT by integrating them together to understand the behavioral intention to use a smartwatch, and therefore, PLS-SEM is regarded to be the best choice when used in such scenarios (Urbach and Ahlemann, 2010). Further, PLS-SEM provides synchronous analysis for the evaluation of the measurement and structural models, which undoubtedly can lead to more precise results (Barclay, Higgins and Thompson, 1995). Besides, this research emphasizes more on the exploration of students' adoption of smartwatches rather than its confirmation (Hair, Ringle and Sarstedt, 2011); therefore, PLS-SEM is an appropriate alternative technique in comparison with others.

5. Results

5.1 Descriptive statistics

The results provided in Table 2 indicate that 53.2% of the participants are females, and 46.8% of them are males. Additionally, 59% of the participants were in the age group of 18-22, followed by 26.5%, 10.5%, and 4% in the age groups of 23-28, 29-35, and above 35, respectively. The results also indicated that 37.4% of the respondents are undergraduate students in year 1, followed by

22.7% in year 2, 14.9% at postgraduate level (i.e., master and PhD), 14% in year 4, and 11% in year 3. All the participants indicated that they have smartwatches, and only 37.2% of them stated that they had used them for educational purposes.

Table 2. Participants' demographic information.

5.2 Common method bias

To ensure that the collected data do not contain common method bias (CMB), the Harman's single-factor with eight variables (perceived severity, perceived vulnerability, self-efficacy, response efficacy, response costs, perceived usefulness, perceived ease of use, and behavioral intention) was carried out (Podsakoff *et al.*, 2003). The eight constructs were then loaded into a single factor. The analysis results pointed out that the largest variance explained by the single factor accounted for 29.21%, which was below the suggested value of 50% (Podsakoff *et al.*, 2003). Hence, the collected data shows no concerns in terms of CMB.

5.3 Measurement model assessment

The assessment of the measurement model was undertaken by evaluating the reliability and validity (including convergent and discriminant validity) of the collected data. The reliability was assessed through Cronbach's Alpha and composite reliability (CR) (Hair Jr *et al.*, 2016). As per the readings in Table 3, no issues were raised in terms of Cronbach's Alpha and CR as all the values were above the threshold value of 0.7 (Hair Jr *et al.*, 2016).

For the convergent validity, it is evident from Table 3 that the values of factor loading were all above the threshold value of 0.7 (Hair Jr *et al.*, 2016). In addition, the values of the average variance extracted (AVE) were all above the threshold value of 0.5 (Hair Jr *et al.*, 2016). Therefore, the convergent validity is confirmed. Concerning the discriminant validity, most of the prior research examined the Fornell-Larcker criterion and cross-loadings. Due to the lack of reliability of these two techniques in detecting the discriminant validity across many situations (Henseler, Ringle and Sarstedt, 2015), this research computes the Heterotrait-Monotrait ratio (HTMT) as an alternative technique. The results in Table 4 showed that all the values were less than the threshold value of 0.85 (Henseler, Ringle and Sarstedt, 2015), and thus, there were no issues regarding the discriminant validity.

The collinearity was also evaluated through the variance inflation factor (VIF) with a threshold value of 5 (Hair Jr *et al.*, 2016). The results pointed out that all VIF values were less than the suggested value of 5, and hence, there were no major concerns in terms of collinearity.

Table 3. Reliability and convergent validity results.

Table 4. Heterotrait-Monotrait ratio (HTMT) results.

5.4 Structural model and hypotheses testing

The research hypotheses were tested by examining the significance of path coefficients (see Table 5) over a bootstrapping procedure of 5000 resamples (Hair *et al.*, 2017). The generated results indicate that perceived severity has an insignificant impact on the students' behavioral intention to use smartwatches. Table 5 shows the results of the assessment of the structural model.

Table 5. Hypotheses testing results.

The results showed that hypothesis 1 ($\beta = 0.048$, $t = 1.344$) is rejected. This shows that perceived severity does not have a significant effect on students' behavioral intention to use smartwatches in their education. The results revealed that hypothesis 2 ($\beta = 0.154$, $t = 3.287$), hypothesis 3 ($\beta = 0.421$, $t = 7.765$), hypothesis 4 ($\beta = 0.108$, $t = 2.277$), and hypothesis 5 ($\beta = 0.176$, $t = 3.852$) are supported. This shows that perceived vulnerability, self-efficacy, response efficacy, and response costs have significant influences on students' behavioral intention. In addition, hypothesis 7 ($\beta = 0.221$, $t = 4.178$) and hypothesis 8 ($\beta = 0.197$, $t = 4.709$) are supported. Hence, the results provided evidence that perceived ease of use and perceived usefulness together have significant impacts on the students' behavioral intention to use smartwatches. Furthermore, hypothesis 6 ($\beta = -0.404$, $t = 10.349$) is supported. Hence, perceived ease of use has a significant effect on students' perceived usefulness of the use of smartwatches. The examination of the R^2 value showed that the proposed model has explained 50.6% of the variance in the behavioral intention to use smartwatches for learning purposes.

6. Discussion

This study aimed to develop a new theoretical model to understand the factors that can affect university students' adoption to use smartwatches for educational purposes. The proposed model

combines factors found in the TAM and the PMT. In doing so, the data were collected from university students in Malaysia. The results of the data analysis supported our proposed model. Moreover, the findings revealed that our proposed model fits well as it has an acceptable explanatory power, and the majority of the factors have significant effects on students' behavioral intention towards using smartwatches for educational purposes. The results showed that security concerns play a significant role in university students' intention to use smartwatches in education. Surprisingly, unlike what we hypothesized, the findings suggested that perceived severity or the negative security consequences do not have a significant effect on students' behavioral intention towards using smartwatches for educational purposes. This contradicts with what was found in previous studies regarding the significance of this factor (Chenoweth, Minch and Gattiker, 2009; Ab Rahman and Choo, 2015; Gao, Li and Luo, 2015; Ameen *et al.*, 2020). On the contrary to our original assumption, students' awareness of the negative security consequences associated with the use of smartwatches does not have a significant effect on their willingness to use them as part of their educational experience.

Our findings showed that perceived vulnerability has a significant effect on students' behavioral intention to use smartwatches for education. This supports the findings of previous studies regarding the significant effects of perceived vulnerability (Siponen, Pahlila and Mahmood, 2007; Chenoweth, Minch and Gattiker, 2009; Ab Rahman and Choo, 2015; Gao, Li and Luo, 2015). This strong effect can motivate students to take security measures to reduce security breaches. In addition, self-efficacy proved to be a significant factor affecting students' behavioral intention. Students' confidence in their use of smartwatches for education and their ability to keep their smartwatches safe is an important determinant for their adoption of these devices for educational purposes. This extends what was found in previous studies regarding the significance of this factor for the adoption of different technologies (Woon, Tan and Low, 2005; Chenoweth, Minch and Gattiker, 2009; Ab Rahman and Choo, 2015; Gao, Li and Luo, 2015; Hsieh *et al.*, 2017; Verkijika, 2018).

Our results showed that response efficacy has a significant impact on the adoption of smartwatches for educational purposes. This shows that students believe in the power of the recommended behavior to avoid security risks associated with the use of smartwatches for educational purposes. These findings are consistent with the findings of previous studies (Chenoweth, Minch and

Gattiker, 2009; Ab Rahman and Choo, 2015; Hsieh *et al.*, 2017; Sergueeva and Shaw, 2017; Ameen *et al.*, 2020). Furthermore, response cost has a significant negative effect on behavioral intention, indicating that students' efforts associated with performing the recommended safe use of smartwatches have a significant effect on their adoption of this technology for educational purposes. Students view the amount of efforts related to their compliance with the recommended safe use of smartwatches as a factor that discourages them from ensuring the security of these wearable devices while using them for educational purposes. This is consistent with the findings of previous studies (Lee, 2011; Dang-Pham and Pittayachawan, 2015; Tsai *et al.*, 2016).

The findings highlighted the significant effect of the ease of using smartwatches for educational purposes as an essential factor for determining students' intention to use these devices. This is consistent with the findings of previous studies (Davis, 1989; Ameen and Willis, 2019; Salloum *et al.*, 2019; Al-Emran and Teo, 2020; Al-Emran, Arpacı and Salloum, 2020; Rafique *et al.*, 2020). Furthermore, the ease of using smartwatches is a significant antecedent that leads students to realize the benefits of this wearable technology for their education. Given that smartwatches are originally personal wearable devices that can be used for multiple purposes including education, the role of ease of use and usefulness becomes even more important in comparison to what was found for the adoption of other technologies (Ameen, 2017; Kamal, Shafiq and Kakria, 2020; Rafique *et al.*, 2020).

Overall, the findings showed that the factors related to the security of smartwatches play an essential role in their adoption by students for educational purposes, along with students' perceptions of the ease of use and usefulness of these devices.

7. Theoretical contributions and practical implications

7.1 Theoretical contributions

The theoretical contributions of this research are twofold. First, this research proposes a new theoretical model by integrating factors related to students' beliefs regarding the security concerns associated with the use of smartwatches for educational purposes and the ease of use and usefulness of these devices. The model is based on combining two of the most cited theories in the areas of technology adoption and information security: the TAM and the PMT. Our findings supported the applicability and significance of the factors integrated into our model. In doing so, the study sheds the light on an unexplored area of research, which is the students' concerns of

security issues associated with their use of smartwatches for their education. Second, the findings of this research revealed that students' awareness of the significant effects of the severity of security threats was associated with their use of smartwatches. Hence, the factors perceived severity, perceived vulnerability, and response cost proved to be significant. Such findings extend what was found in previous studies, which mainly concentrated on the secure use of technology in an organizational setting (Ameen *et al.*, 2020). Overall our study showed that these factors are important for students' use of smartwatches as part of their learning experience.

7.2 Practical implications

Our findings have practical implications for universities and higher education institutions. First, despite the widespread use of smartwatches for various purposes such as health and communication, the use of this wearable technology has not been sufficiently investigated in the context of university students' education. Our findings reveal that students are open to the use of this technology for educational purposes. Moreover, the findings revealed that this technology could be used in more innovative ways in comparison to other technologies such as PCs, laptops, or iPads. Hence, educators and instructors are encouraged to find new and innovative ways to make use of such technology.

Our findings also indicated that universities and instructors should clearly explain the security concerns associated with the use of smartwatches for educational purposes. In fact, it is recommended that students should follow clear policies and guidelines that can enable them to securely use these devices. Furthermore, these policies and guidelines should be easy for the students to follow and should highlight the consequences and security threats students may face if they are not followed and how this can have a negative impact on their learning experience.

Educators and instructors are encouraged to boost students' confidence in using such a new and innovative technology for educational purposes as it is an important factor that can increase students' intention to adopt this technology. In addition, clear instructions on how to use this technology for educational purposes should be provided and highlight its benefits, since this helps students to realize the benefits associated with its use to enhance their learning experience. In addition, universities should provide educators and instructors with training courses on how wearable devices, including smartwatches can be used in a more innovative way in a classroom environment. Given that a variety of applications can be accessed through smartwatches, different

activities can be planned to enhance students' learning within and beyond the classroom environment. This will help universities to ensure their continuity and sustainability.

8. Limitations and future work

In terms of the research limitations and future work, a number of caveats need to be highlighted and considered. It was beyond the scope of this research to investigate the educators' behavioral intention to use smartwatches. Therefore, this calls for further research to examine the educators' intention to use these wearables for teaching purposes. This research focused on only one developing country in terms of data collection. It is therefore suggested that further research would be encouraged to test the applicability of the proposed research model in other developing and developed countries. It is unfortunate that this research did not conduct interviews with the respondents. Future studies might take this point into account as interviews would strengthen the generated quantitative results. This research concentrated on the integration of TAM and PMT without considering other external or contextual factors. Future trials might bridge this gap by extending the two theories with other constructs in an attempt to further strengthen the integration of the two models and provide more insightful results.

9. Conclusion

A plethora of research has focused on the use of different technologies in higher education. However, exploring the use and security concerns among university students remains a gap in existing research. This study aimed to bridge a gap in research on the role of security factors in students' use of smartwatches for educational purposes. Given the unique features of this technology and the amount of personal data involved in their use, we believe focusing on this topic helps to advance research in this area. The findings of our research indicate that while students enjoy the benefits and usefulness of these devices, the security concerns associated with the use of this technology remain a challenge. The study provided interesting and new insights for academics and educators on the potential use of smartwatches in higher education and the security measures that can be undertaken to ensure their safe use.

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Appendix: Constructs and items

Behavioral intention

BI1: I intend to start using the smartwatch to interact with my colleagues and lecturers.

BI2: I will strongly recommend the use of smartwatch to my peers.

BI3: I will always try to use a smartwatch at my university on a daily basis.

BI4: Overall, I intend to continue using the smartwatch in my future learning.

Perceived ease of use

EoU1: Smartwatch is flexible to interact with.

EoU2: Every feature and function in the smartwatch is easy to understand.

EoU3: Overall, using smartwatch in learning activities is easy for me.

Perceived usefulness

PU1: It would be convenient for me to have a smartwatch.

PU2: Using smartwatch increases my learning achievement.

PU3: I think smartwatch can help me in performing my learning activities.

PU4: Overall, smartwatch is useful to me.

Perceived severity

PS1: I believe that learning material stored on a smartwatch is vulnerable to security incidents.

PS2: I believe that the productivity of smartwatch is threatened by security incidents.

PS3: I believe that the profitability of smartwatch is threatened by data protection incidents.

PS4: I believe that smartwatch can allow remote access to learning materials.

PS5: I believe that smartwatch can be used to download learning materials.

Perceived vulnerability

PV1: Smartwatch could be vulnerable to security incidents.

PV2: Smartwatch could be susceptible to security incidents.

PV3: A security problem to my personal data could occur if I don't comply with the institution's smartwatch security policy.

Response costs

RC1: Smartwatch is expensive to purchase and operate.

RC2: We have to frequently upgrade our smartwatches to download learning materials.

RC3: Security incidents can slow down the smartwatch performance.

RC4: Compliance with smartwatch security policy would require a considerable investment of effort other than time.

Response efficacy

RE1: Smartwatch can successfully prevent security incidents.

RE2: Smartwatch is the best solution for counteracting security problems.

RE3: If we use the smartwatch in our study, we can minimize the threat of security incidents.

RE4: Compliance with smartwatch security policy reduces the security threat to my personal data.

Self-efficacy

SE1: It would be easy for me to use the smartwatch by myself.

SE2: I could adopt the smartwatch even if there is no one around to tell me what to do as I go.

SE3: I could adopt the smartwatch if I could contact someone when I got stuck.